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VIII. For nebular spectrographic work the integrating spectrograph (one in which the image-forming or condensing lens is of zero dimensions), is the best possible form for securing a maximum contrast.

IX. In stellar spectrographic as well as in stellar photographic work, the "condensing" (telescope) objective should have the largest possible angular aperture.*

X. As regards the influence of the character of the objective (II (2)) upon the illumination of the field, the refractor seems to have a decided advantage. The angular aperture of the latter should not, however, be greater than 1-5. To photograph the very faintest star (beyond 17th magnitude) a reflector of the largest possible angular aperture, 1-3 or 1-2 if possible, is the only instrument that can be used. For stellar spectrographic work, in which only a small field is required, the reflector of large angular aperture is greatly superior to the refractor.†

Yerkes Observatory:
1897 *June* 3.

A Note on Spider Lines. By F. L. O. Wadsworth, Astrophysicist, Yerkes Observatory.

(*Communicated by the Secretaries.*)

Apropos of the present discussion on the straightness of spider lines—see paper by Professor Turner in the last (April) number of the *Monthly Notices*—it may be well to point out that whether such an effect has ever been observed or not, it would be well to guard against its possible occurrence by using for the cross wires in our instruments something of a more reliable and permanent nature than the usual spider web. This, although very fine and strong, has so many and such grave disadvantages as to make one wonder how it has ever been tolerated as long as it has. Formerly perhaps it might have been said that there was no thoroughly satisfactory substitute; even the finest metal wires prepared by the so-called Wollaston process being too coarse, and silk having the same disadvantages as spider line itself in the way of hygroscopicity and semi-translucency. Now, however, the invention of the quartz fibre by Boys has provided us with something

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* In connection with this point see also my paper, "General Conditions respecting the Design of Astronomical Spectroscopes," in the first number of the *Astrophysical Journal*, Jan. 1895, p. 52 (particularly pp. 70–71).

† For other advantages of the reflector see also paper by Professor Hale in a recent number of the *Astrophysical Journal* (Feb. 1897, p. 119), and various papers by the writer in the *Phil. Mag.* (vol. xxxviii. pp. 137 and 337), *Astronomy and Astrophysics* (vol. xiii. p. 835), and the *Astrophysical Journal* (vol. i. p. 232; vol. ii. p. 370; vol. iii. p. 169 [particularly pp. 182 and 183]; vol. iii. p. 347; &c.).

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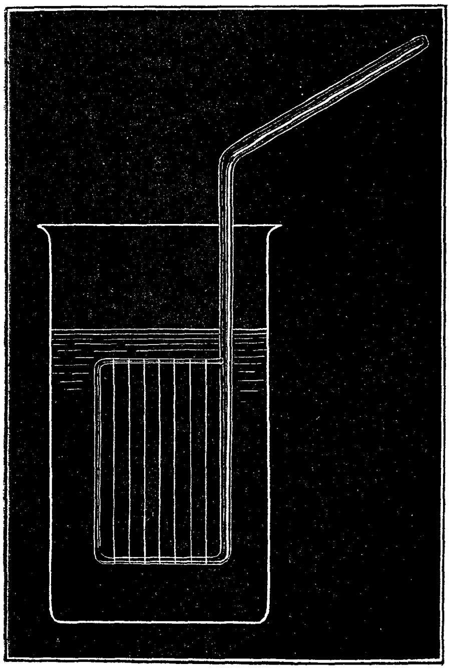
which is not only entirely unaffected by atmospheric changes, but also superior to spider line, and, in fact, to all other known fibres, in strength and fineness. The quartz fibres themselves are transparent, but this difficulty is removed, and the fibres made more easily visible for handling and mounting as well, by silvering them by any of the well-known silvering processes. When properly silvered they are perfectly opaque, even in the most strongly illuminated field.

I do not know who first proposed the use of silvered quartz fibres for this purpose, but their obvious advantages must have suggested their use for this and many similar purposes (such as fine plumb and level lines, &c.) to many others besides myself. I first used them for the cross wires of an observing telescope about five years ago, while a student at Clark University. It is hardly necessary to say that I have continued to use them ever since whenever it was possible to obtain or make them, and I know of many others whose experience has been equally satisfactory. Nevertheless, they do not yet seem to be as generally known and widely used as they ought to be. It is sometimes difficult to obtain sufficiently fine fibres from dealers, at least in this country; but anyone can, after a little practice, make them for himself, the only really essential things being a good oxyhydrogen blow-pipe and a supply of reasonably pure hydrogen (coal gas is very unsatisfactory), and oxygen in pressure tanks. These requisites can now all be readily obtained from any good dealer in projection apparatus. Many plans for "shooting" the fibres have been proposed, but I have never found anything more simple or satisfactory than the original bow and arrow method of Pro-



Frame for silvering quartz fibres.

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fessor Boys. See paper "On the Production Properties and Some Suggested Uses of the Finest Fibres," *Phil. Mag.* 1887 June.

For silvering them I prefer Brashear's method (described at length in a paper by the writer, "On Silvering Solutions and Silvering," *Astrophysical Journal*, vol. 1, page 252, 1895 March). To get a good coat it is, however, necessary to clean the fibre very carefully. For this purpose I have found it best to use in succession very hot solutions of strong nitric acid and strong potash, and then wash in several changes of clean distilled water before immersing in the silvering solution. In order to handle the fibres during these operations I have found it convenient to mount them on a small rectangular glass frame with a bent handle, similar to that shown in the figure. The ends of the fibres are secured to the upper and lower bars of the frame by fused (not dissolved) shellac, which resists well the action of the hot acid and alkali. In lifting the frame in and out of the solutions care should be taken to move it vertically up and down, otherwise the fine fibres will be broken by the surface tension of the liquid surface. On such a frame a dozen fibres may be silvered at once, and then set aside for use as desired.

Another great advantage which such silvered fibres would be likely to possess when used in bright wire micrometers, *i.e.* that of perfect and uniform illumination, was pointed out by Professor Burnham in the course of a recent conversation with the writer on this subject. To get the best results in such a case a cylindrical mirror should be placed behind the wire (on the side away from the source of illumination) with its axis parallel to the length of the wire.

Yerkes Observatory:
1897 *May* 29.

Notes on the Reduction of Stellar Photographs.

By Prof. Arthur A. Rambaut, M.A., D.Sc.

All who have closely followed the recent developments in the use of photography as a means of measuring the positions of stars must have been impressed with the great value of the methods proposed and advocated by Professor Turner in the several papers which he has published on the subject.

From the point of view taken up by him—which is in the main that of a partaker in the International Photographic Survey of the Heavens, although many of his results have a wider application and are largely useful in facilitating operations and increasing accuracy whatever the object of research may be—from this point of view it is difficult to see in what way much further simplification in the reduction of the plates is to be introduced.